EFFECT OF MOLYBDENUM CONCENTRATION AND SPRAYING STAGES ON SEED YIELD AND ITS COMPONENTS OF ALFALFA

Naseer F. Shachai **Rzan Z. A.AI-Beiruty** **Hameed. KH. Khrbeet**
Lecturer **Assist Prof.** **Prof.**
Dept. Field Crops – Coll. Agric. – Engin. – Sci. University of Baghdad
naser.faraj@coagri.uobaghdad.edu.iq albeiruty @coagri.uobaghdad.edu.iq
hameed.khalaf@coagri.uobaghdad.edu.iq

ABSTRACT

A field experiment was carried out at the experimental field in the College of Agricultural Engineering Sciences, University of Baghdad, Iraq from beginning of October 2020 to the end of August 2021. The main objective was to find out the effect of Molybdenum (Mo) concentrations (0, 20, 40 and 60 mg L^{-1}) and three stages of foliar application (vegetative growth, flowers buds appearance and 25 % blooming) on seed yield and it's component of alfalfa local variety. layout of the experiment was R. C. B. D. arranged in split-plot, with three replicates. Spraying stages were used as main-plots. while Molybdenum concentrations were used as sub-plots. Results revealed that foliar application of Mo at concentration More than 20 mg L^{-1} (40 and 60 mg L^{-1}) resulted in a significant increment in the No. of florets raceme^{-1}, No. of pods raceme^{-1}, No. of seeds pod^{-1}, No. of racemes stem^{1}, Biological yield, seed yield and harvest index. Highest seed yield (502.0 k ha^{1}) was obtained when Mo sprayed at level 40 mg L^{-1}.Plants sprayed at flowers buds emergence produces highest seed yield (492.6 k ha^{-1}), No. of pods raceme^{-1}, No of seed pod^{-1} and No. of racemes stem, which show high positive correlation with seed yield (+ 0.72,+ 0.49** and +0.49*) respectively. This results may be indicating that these traits could be used as good selection criteria for breeding and improving seed yield in alfalfa. The higher seed yield (567.5 kg ha^{-1}) was obtained when alfalfa plants were sprayed with Mo at concentration 40 mg L^{-1} in flowers buds emergence.**

Keywords: florets abortion, seed set, trace elements, flowering, foliar application

تأثير تراكيز الموليبدينم ومراحل الرش في حاصل البذور ومكوناته في الجت

نصير فرج شجاي رزان زهير البيروتي حميد خلف خربيط
مدرس استاذ مساعد استاذ

المستخلص

اجريت هذه الدراسة في حقول كلية علوم الهندسة الزراعية – جامعة بغداد للمدة من بداية شهر تشرين اول 2020 – نهاية أب 2021 وذلك لدراسة تأثير تراكيز مغذي المولبيدنيم (0 و 20 و 40 و 60 ملغم لتر$^{-1}$) ومراحل الرش (مرحلة النمو الخضري و ظهور البراعم الزهرية و 25% تزهير) في حاصل بذور الجت (الصنف المحلي) نفذت التجربة حسب تصميم القطاعات العشوائية الكاملة بتريتب الالواح المنشقه وبثلاثة مكررات. اذ تضمنت مراحل الرش الالواح الرئسيه وتراكيز المولبيدنيم الالواح الثانوية. أظهرت نتائج هذه الدراسة أن رش هذا المغذي بتركيز أعلى من 20 ملغم لتر$^{-1}$ (40 و 60 ملغم لتر$^{-1}$) قد ادى الى زيادة معنوية في عدد الزهيرات بالنورة الزهرية وعدد القرنات بالنورة وعدد البذور بالقرنة وعدد النورات الزهرية بالساق الواحد والحاصل البيولوجي وحاصل البذور ودليل الحصاد. كان أعلى حاصل بذور عند رش المغذي بتركيز 40 ملغم لتر$^{-1}$ بلغ 502.0 كغم هـ$^{-1}$ كما أظهرت النتائج أن رش هذا المغذي عند مرحلة ظهور البراعم الزهرية قد أدى الى زيادة معنوية في حاصل البذور اذ بلغ 492.6 كغم هـ$^{-1}$ وفي عدد القرنات بالنورة, عدد البذور بالقرنة وعدد النورات بالساق الواحد اذ أرتبطت هذه الصفات معنويا مع حاصل البذور أذ بلغت قيمة الأرتباط (0.72+ و **0.49+ و *0.49+) بالتتابع لذلك من الممكن استعمال هذه المكونات كمعيار لتربية أصناف من الجت عالية الحاصل للبذور . تم الحصول على أعلى حاصل من البذور (567.5 كغم.هـ$^{-1}$) عند رش هذا المغذي بالتركيز40 ملغم لتر$^{-1}$ عند مرحلة ظهور البراعم الزهرية.**

الكلمات المفتاحية: اجهاض الزهيرات، عقد البذور، العناصر الصغرى، التزهير، الرش الورقي .

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INTRODUCTION

Alfalfa (*Medicago Sativa* L.) is one of the most important forage legumes in Iraq. it is well known capability of nitrogen fixation, couples with it has advantage over grasses in terms of quality for animal feeding due it is content of higher percentage of protein and higher level of digestibility .In Iraq, alfalfa normally sown for forage production and seed yield is considered to be secondary important. The mean seed yield under Iraqi condition is low, no more than 250 kg ha^{-1} Khrbeet, H.K,et al(8) and(9). This low productivity could be attributed mainly to a lack of suitable guide lines for its management, particular during the critical period of seed crop. The farmers in the country, have little knowledge related to nutrient managements, The exhaustive removal of nutrients, sluggish nodule development due to frequent cutting before release the crop for seed set may lead reduction in food materials reserves in roots and crowns, this may be in enhance new vegetative organs rather keep those reserve toward seed set and seed formation. All nutrients must be available in sufficient quantity in order to be able to get satisfactory seed yield(5,23). Number of field studies reported that application of certain micronutrients, Molybdenum (Mo) play an important role in the metabolisms of plants, but it is role in promoting nitrogen fixation through its effect on rhizobia growing symbiotically with legumes is of particular agricultural importance, especially in recent years when such source of nitrogen became more importance. Mo plays an important role in nitrogen (N) metabolism in general and N fixation in legume species in particular Xiaotao Mao's et al (17). And It is also play vital role in absorption and translation of iron in the plant (18). In studies of Du,etal.(4), Mo increased alfalfa seed yield from 27 to 47 %, the number of racemes per stem from 38 to 55 % , number of pods per raceme 100-113% , the number of seed per pod 48 to 61 % and 1000 seeds weight by 14% , They also found that high seed yield was obtained when Mo sprayed at flower – bud emergence stage , but it could not achieve the level of significant compare to vegetative growth and 20% flowering stage. There was no study carried out under Iraqi condition to know the effect of foliar application of Mo on seed yield and its' components of alfalfa in order to increase the availability of alfalfa seeds to meet the serious shortage in green forages by increasing the area cultivated with alfalfa crop.

MATERIALS AND METHODS

A field experiment was carried out at experiment afield at field Crop Department. College of Agricultural Engineering Sciences, University of Baghdad during the period from beginning of October 2020 to end of August 2021 to investigate the effect of different concentration of Molybdenum (Mo) and the foliar application stages on seed yield and it's components in Alfalfa . Soil properties of the field are show in Table1.The experiment was carried out in the base on split plot design with three replicates. Three stages of spraying of Mo {vegetative growth (two weeks after mowing), flower buds appearance and 25% flowering} were used as main plots and four levels of Mo (0 , 20 , 40 and 60 mg L^{-1}) as sub- plots referred as (Mo_0 , Mo_1, Mo_2 and Mo_3) respectively (ammonium Molybdate 54% was used as source for Mo. Before sowing all plots received fertilizers of P, K and S as recommended (9,10) in order to get good establishment of stands . In the beginning of October 2020 seeds of local cultivas were established in 60 cm drills at seed rate 8 kg ha^{-1} (9). Each sub plot consist of 7 rows, each four meter along. The first cutting was made after over winter on lst March 2020 (13) in order to remove all the annual winter weeds and support the alfalfa growth The subsequent cutting was made when plants reached the 15-20 % blooming stage. Last cutting was made on the mid. May of 2021 and the crop left for seed set because this time lead the plants to reach flowering on the best time for insects pollinators. The intervals of Irrigation were organized and last irrigation was done when the stands reached at beginning of pod formation (13)and (khrbeet et al, (10). spraying Mo levels (0 , 20 ,40 and 60) mg L^{-1} was applied according to the growth stages, vegetative, flower buds emergence and 25% blooming.

Biological measurements

In each sub – plot when the stands reached full bloom stage, forty racemes were randomly

selected from middle rows to calculate the number of florets per raceme. Quadrate (0.6 m^2) was taken from the middle rows and harvested when majority of pods had turn brown (7). to determine the number of stems per quadrate and then convert to m^{-2}.fifty stems were chosen at random and following seed yield component were determined:

1- Number of racems $stems^{-1}$

2- Number of pods $raceme^{-1}$

3- Percentage of florets abortion was determined according to the following equation:

$$\text{Abortion } \% = \frac{Number\ of\ florets - number\ of\ pods}{\text{Number of florets}} \times 100\%$$

4- Number of seeds pod^{-1}

5- 1000 seeds weight (g) (T.S.W)

6- Seeds yield were estimated from middle lines, drying was made at the field and threshing was made by hand.

All data collected from this experiment were analysed according to analysis of Variance method as described by Steel and Torrie (17) . Means were compared using L.S.D at the 5% level of significant. Simple correlation analysis was carried out using SPSS software version 20.

Table 1. Some chemical and physical properties of soil before planting

Property	Value	Unit
Electrical conductivity 1:1	**3.8**	**ds m^{-1}**
PH	**7.23**	
N	**24.10**	
P	**11.34**	**mg kg^{-1} soil**
K	**70.80**	
Molybdenum	**0.04**	
Soil texture	**Silty clay loam**	

RESULTS AND DISCUSSION

NO. stems m^{-2}

There was no significant effect of Molybdenum (Mo) on number of stems m^{-2}, but this trait was significantly influened by Foliar application stages and the interaction between the Two factors (Table 2). The number of stems m^{-2} did not significantly affected owing to application of different levels of Mo, Although, higher number of stems m^{-2} were obtained under Mo treated plots but they could not achieve the level of significance compare to control plots.These results are in agreement with the result found by Yadav (19). Foliar application at vegetative stage gave higher number of stems per m^{-2} reached (220.4) and differed significantly compare with flower bud emergence (204.1) and 25% flowering (196.0) which did not significantly different to each other. Such enhancement effect of nutrient when sprayed at vegetative growth probably due to a sufficient time given for the plant to absorb the nutrient to contribute in plant biological processes. (Table 2) also shows a significant interaction between the two factors. The reason behind this interaction may be due to the difference in relative response to Mo concentration in different spraying stages as it was generally noted that, spraying of Mo at vegetative growth and flower bud emergence increased steadily with increase in Mo concentration, while in late spraying stage (25% flowering) this trait increased steadily and reach the peak at MO_2 and their after it was significantly decreases at MO_3.

Table 2. Effect of Mo concentrations, foliar application stages and their interaction on mean NO. stems m^{-2}

Con. of Mo mg L^{-1}	Number of racemes per stem Foliar application stages veg. growth	Flower bud emergence	25% flowering	Mean
0	**193.7**	**190**	**189.5**	**191.1**
20	**211.6**	**203.6**	**194.3**	**208.2**
40	**226.9**	**208.9**	**216.4**	**217.4**
60	**249.2**	**214**	**191.8**	**218.8**
L.S.D 5%		**17.70**		**NS**
Mean	**220.4**	**204.1**	**196.0**	
L.S.D 5%		**10.16**		

Number of racemes per stem and Number of seeds per pod.

Those two parameters have been identified as the most components influencing seed yield in alfalfa (18).(Table 3) shows that, plants which did not received Mo (Mo_0) produced significantly fewer number of racemes per stem (10.87) compare with other concentrations Mo_1,Mo_2 and Mo_3. Foliar application with other concentrations increases the number of racemes per stem reach the peak at concentration 40 mg. L^{-1} (Mo_2) amounted to (14.2). Increases the concentration beyond that limit significantly reduce this trait. Mo is a component of the enzyme nitrogenase which is required in nitrogen fixation and play a role in phosphorus utilization (1) Yadav (19) in brseem and Du,etal. (4) in alfalfa also reported that the Mo levels had significant effect on number of racemes per shoot. spraying with Mo indicated a significant effect of spraying stages on this trait as spray stage at flower bud emergence gave highest mean of racemes per stem (13.56) and it was significantly different than vegetative growth (11.92) and 25% flowering stage (12.12) which did not significantl different to each other Concerning the significant interaction between the two factors may be interpreted based on the differences in the relative response of each spraying stage and different concentrations. (Table3) shows that spraying Mo had significant effect on number of seeds per pod, plants which did not receive Mo (Mo_0) produced lower number of seeds per pod (3.68) and it was significantly different compare with other concentration, plant which receive high conc. of Mo produced high number of seeds per pod (4.53), but did not significantly different compare with Mo_1, and Mo_2 . The same results were observed by Dhaliwal etal (2) and khrbeet etal. (8) in berseem and Du, etal. in alfalfa (4). spraying with Mo indicated significant effect of spraying stages on number of seeds per pod. Maximum seed set was occurred when plants sprayed at flower–bud emergence stage reached (4.52)., but it was only significantly different compare with vegetative growth (3.86). There was no significant interaction between the two factors on number of seeds per pod.

Table 3. Effect of Mo concentrations, foliar application stages and their interaction on mean number of racemes per stem and number of seeds per pod

Con. of Mo mg L^{1-}	Number of racemes per stem Foliar application stages veg. growth	Flower bud emergence	25% flowering	Mean	Number of seeds per stem Foliar application stages veg. growth	Flower bud emergence	25% flowering	Mean
0	**10.70**	**11.20**	**10.73**	**10.87**	**30.60**	**3.83**	**3.63**	**3.68**
20	**11.20**	**13.10**	**11.90**	**12.20**	**4.03**	**4.60**	**4.16**	**4.26**
40	**13.32**	**15.90**	**13.40**	**14.20**	**3.86**	**4.70**	**4.40**	**4.32**
60	**11.96**	**13.93**	**12.36**	**12.76**	**3.06**	**4.96**	**4.66**	**4.53**
L.S.D 5%		**0.79**		**0.44**		**NS**		**0.29**
Mean	**11.92**	**13.56**	**12.12**		**3.86**	**4.52**	**4.12**	
L.S.D 5%		**0.57**				**0.34**		

Number of florets per raceme, pods per raceme and % of florets abortion

Alfalfa plants produce many florets per raceme, In general there are twelve to twenty five, but only half or less number developed successfully into pods. Results show in (Table 4) indicated that Mo concentration had significant effect on number of florets per raceme and No. of pods per raceme, while% of florets abortion was not significantly influenced by Mo concentration .plants which did not receive Mo (Mo_0) produce fewer florets per raceme (14.3) and fewer pods per raceme (9.53). In both parameters, increases in the concentration of Mo significantly increases of florets and pods peak raceme reach the per at concentration Mo_3 (18.42) and (13.24) respectively. Suggesting that increases in the concentration of Mo higher than used in this experiment could be useful in increase of those two parameters. Spraying of Mo at concentration 20, 40 and 60 mg L^{-1} compare with Mo_0 resulted in an increase in number of florets and pods per raceme by (11.4% , 21.8% and 29.7%) and (11.8% , 32.8% and 38.9%) respectively. Such increases could be due to the fact that Mo involve in maintenance of some physiological enzymes activity that leads to easy translocation of assimilate to reproductive organs like flowers and pods (12). Similar findings were also reported by Du, etal. in alfalfa (4), Tahir in black gram

(17) and Yadav in Berseem. Table (5) shows that spraying stages had significant effect on each No. of florets per raceme and % of florets abortion, while No. of pods per raceme were not significantly by spraying stages. Foliar application of Mo at vegetative growth gave highest No. of florets per raceme (17.78), but it was not significantly different than flower buds emergence (16.70) and both significantly different than 25% flowering which produce only (14.78) it seems that this trait was decreas with delaying of foliar application of Mo. Such reduction probably due to that delay in spraying may reduce the benefit from the nutrient because it never gave a sufficient time for the plants to absorb the nutrient. (Table 5) shows spraying Mo at flowers buds emergence stage had lowest % of florets abortion (27.49%) and it was only significantly different compare with vegetative growth stage 35.01%).

Table 4. Effect of Mo concentrations on mean number of florets per raceme, number of pods per raceme and % of florets abortion

Molybdenum Conc. mg L^{-1}	No. of florets per raceme	No. of pods per raceme	% of florets abortion
0 (Mo_0)	14.3	9.53	32.11
20 (Mo_1)	15.82	10.66	34.01
40 (Mo_2)	17.30	12.66	29.58
60 (Mo_3)	18.42	13.24	28.02
L.S.D 5%	1.07	0.64	NS

Table 5. Effect foliar application stages on mean number of florets per raceme, number of pods per raceme and % of florets abortion

Foliar application stages	No. of florets per raceme	No. of pods per raceme	% of florets abortion
Vegetative Growth	17.78	11.79	35.01
Flower buds emergence	16.70	12.17	27.49
25% flowering	14.78	10.27	30.30
L.S.D 5%	1.28	NS	‘5.17

Biological yield kg ha^{-1}

Results in (Table 6) reveal that foliar application of Mo at different concentration and stages had significant effect on biological yield, while the interaction between the two factors was not significant. Biological yield was significantly increased with increase in Mo concentration. foliar application of Mo at conc. 20, 40, and 60 mg L^{-1} resulted in increase in biological yield by 10.9%, 15% and 22% when compare with control treatment (Mo_0) respectively.in this field experimented it seems most of Biological components were influenced by Mo. such as, number of stems per unit area, number of raceme per stem and number of pods per raceme. all these parameters show high positive correlation with biological yield (Table 9). Increase biological yield after foliar application of Mo at high level 60 mg L^{-1} is due to increase all these component. other component of biological yield, such as plant height and leaf area which are not counted in this field exp. were also influenced by foliar application of Mo, Rajesh (12) found that foliar application of Mo on gram significantly increase plant height, leaf area and dry weight. Similar results were obtained by kumar etal. (11) in black gram and Yadav (19) in berseem. concerning the effect of foliar application stages Table (6) shows that highest biological yield were obtained when plant sprayed at vegetative growth (6453 kg ha^{1}), but it was not significantly differented than flower bud emergence stage (6320 kg ha^{-1}) and both were significantly different compare with 25% flowering stage (6118 kg ha^{-1}). The reduction in biological yield could be due to that delaying in foliar application of Mo may never give enough time for plants to absorb the Mo and transfer it to active regions from that stage to take their role in metabolic process. Similar findings were also reported on red clover by Frolova and Grmzikov (5).

Table 6. Effect of Mo concentrations, foliar application stages and their interaction on mean Biological yield

Con. of Mo mg L^{-1}	Number of racemes per stem Foliar application stages veg. growth	Flower bud emergence	25% flowering	Mean
0	5712	5600	5524	5612
20	6532	6398	5745	6225
40	6528	6405	6429	6454
60	7043	6877	6773	6898
L.S.D 5%		NS		208.4
Mean	6453	6320	6118	
L.S.D 5%		261.3		

Seed yield kg ha^{-1}

Results in (Table 7) reveal that foliar application of Mo, foliar application stages and their interaction had a significant effect on seed yield. Plants which did not received Mo (Mo_0) produced lower seed yield (385 kg ha^{-1}) and it was significantly lower from all other concentration of Mo. Highest seed yield was produced from plants sprayed with Mo at concentration 40 mg L^{-1} (Mo_2) (502.0 kg ha^{-1}) and it was significantly different compare with other concentration. Foliar application of Mo at concentration 20,40 and 60 mg L^{-1} resulted in increase in seed yield by 13.1%, 30.4% and 26.2% when compare with Mo_0, respectively. In this field experiment it is clear that all seed yield components were influenced by Mo, number of stems per unit area, number of racemes per stem, number of florets per raceme, number of pods per raceme and number of seeds per pod are the most components, which show high positive correlation with seed yield (0.68**, +0.49*,0.77** , +0.72*,0.49**) respectively (Table 9), These results are in agreement with those reported by Yadav, (19) Dhaliwal, etal. (2) in berseem, and Du, etal (4) in alfalfa.and this consist with Xiaotao Mao et al(18) These findings highlight that application of Mo fertilizer can be an effective way to improve alfalfa production .The same results given by Khrbeet, H.K.et al (8) As proven Dikareva, *E.M.* .et al.(3) Seed yield increases with increasing Mo concentration .(table 7) shows that highest seed yield were obtained when plants sprayed at flower bud emergence (492.6 kg.ha^{-1}) and it was significantly different compare with vegetative growth (427.5 kg ha^{-1}) and 25% flowering stages (436.6 kg ha^{-1}) which were not significantly to each other. It is clear that foliar application of Mo on alfalfa seed crop is more active when it is sprayed at flower bud emergence under Iraqi condition, this result probably due to the role of Mo in increase rate of translocation of photosynthesis towards the flowers and seed development.Similar results were recorded by others (6,8,9).(Table 7) shows significant interaction between the two factors, the reason behind this interaction probably due to the different response to Mo conc. by different spraying stages as it is appear that in all spraying stages, seed yield increased with increase in Mo conc. up to Mo_2 and them decreases at Mo_3, but such decrease was More clear at flowering bud emergency compare with other spraying stages.

Table 7. Effect of Mo concentrations, foliar application stages and their interaction on mean Seed yield

Con. of Mo mg L^{1-}	Number of racemes per stem Foliar application stages veg. growth	Flower bud emergence	25% flowering	Mean
0	383.8	392.0	379.2	385.0
20	414.6	467.3	425.1	435.7
40	463.2	567.5	475.4	502.0
60	448.3	543.4	466.6	486.2
L.S.D 5%		29.17		12.95
Mean	427.5	492.6	436.6	
L.S.D 5%		27.02		

Harvest Index

Harvest index is the ratio between economic yield and biological yield. In this field experiment both the components are increased after foliar application of Mo, but such increase was more in economic yield. Highest harvest index was obtained in plants sprayed with Mo at conc. Mo_2 (40 mg L^{-1}) reached 7.8% and it was significantly different compare with other concentration. control treatment (Mo_0) gave lowest harvest index (6.8%), but it was not significantly different than Mo_1 and Mo_3 (Table 9).Concerning the effect of foliar application stages (Table 8) indicated that the highest mean of harvest index were obtained when plants sprayed at flower bud emergence (7.7%) and it was significantly different compare with vegetative growth (6.6%) and 25% flowering (7.1%), which did not significantly different each other. The increase of harvest index at conc. Mo_2 and the flower bud emergence. May be due to increase of seed yield (Table 7) which show high positive correlation between seed yield and harvest index (+0.76) Table (Table 9) indicated a significant interaction between the two factors and the reason behind that could be due to the different response to Mo conc. by different spraying stages, as it clear that harvest index increase with increas in Mo conc. up to Mo_2 and then decreases at Mo_3. but such decreases more clear at flower bud emergence compare with other spraying stages.

Table 8. Effect of Mo concentrations, foliar application stages and their interaction on mean harvest index

Con. of Mo mg.L^{1-}	Number of racemes per stem Foliar application stages veg. growth	Flower bud emergence	25% flowering	Mean
0	6.7	6.9	6.8	6.8
20	6.3	7.2	7.5	7.0
40	7.1	9.0	7.3	7.48
60	6.3	7.8	6.7	6.9
L.S.D 5%		0.6		0.3
Mean	6.6	7.7	7.1	
L.S.D 5%		0.6		

Table 9. Simple correlation coefficient of seed yield components traits and other in alfalfa. SEY, seed yield, NST, number of stems per unit area, NFR, number of florets per raceme, NPR, number pods per raceme, % FAB,% florets abortion, NSP, number of seeds per pod, NRS, number of raceme per stem, BIOY, Biological yield, HI, Harvest index

Traits	NSA	NFR	NPR	%FAB	NSP	NRS	BIOY	HI
SEY	0.68**	0.77**	0.72*	-0.06 NS	0. 49 NS	0.49*	0.60*	0.76
NST	-	0.73**	0.62*	-0.02 NS	0.06 NS	0.28*	0.30*	-0.10
NFR		-	0.83**	0.03 NS	0.20 NS	0.44*	0.53*	0.07
NPR			-	0.47*	0.43*	0.61*	0.73**	0.36
%FAB				-	-0.44*	-0.38*	-0.45*	-0.50
NSP					-	0.61**	0.69**	0.46
NRS						-	0.94**	0.79
BIOY							-	-0.02
HI								-

NS : Not significant
***: significant at 5% level**
****: significant at 1% level**

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